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(54) Information recording device, record carrier and information reading device.

(57) An information recording device for recording time-synchronous information pieces is disclosed, particularly audio information pieces which are applied as continuous and time-synchronous information steams to an output of the recording device at arbitrary intervals. The recording device comprises search means (25, 26) for searching given portions of a track (2) on the record carrier (1). The searched trck portion is scanned by means of a write head (4), while a signal processing circuit (28) is coupled to the input (27) for receiving the supplied information stream. Prior to providing the information pattern, a control unit (26) realises a search of an intermediate portion in the track (2) released for recording. The released intermediate portion is located between track portions in which the presence of an information pattern which is already present is to be maintained. An information pattern representing the supplied information stream is provided in the searched intermediate portion. The device is provided with an input buffer (29) for decoupling the information stream received at the input (27) and the write signals supplied by the write head (3). The input buffer (29) is coupled to the input (27) for receiving the information stream and an output which is coupled to an input of the write head (3). When the intermediate portion is being scanned, it is detected whether a position in the intermediate portion located near the end of the intermediate portion is reached. In response to the detection the provision of the information pattern is interrupted and the information stream from the input buffer to the signal processing means is also interrupted. In response to the detection a further released portion of the track is searched. The supply of information from the input buffer (29) and the recording are subsequently resumed.

Furthermore, a reading device for reading the information thus recorded is disclosed. The reading device has an output buffer (96) for decoupling a read signal supplied by a read head (92) and the information supplied time-synchronously at an output (98).

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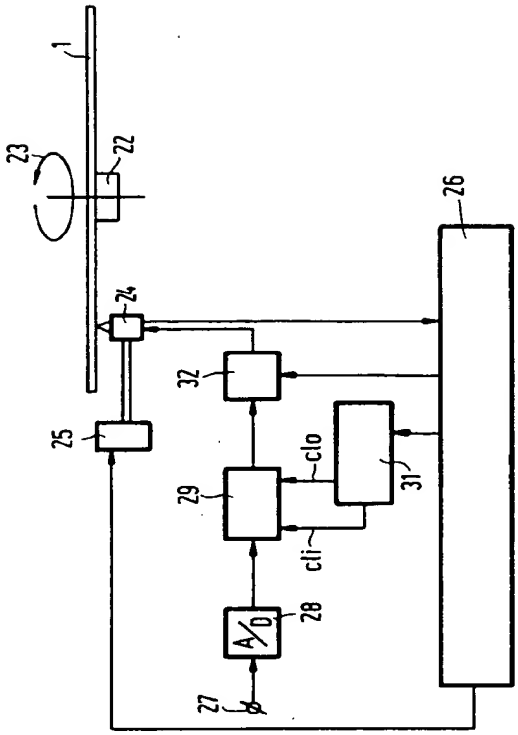

FIG.2

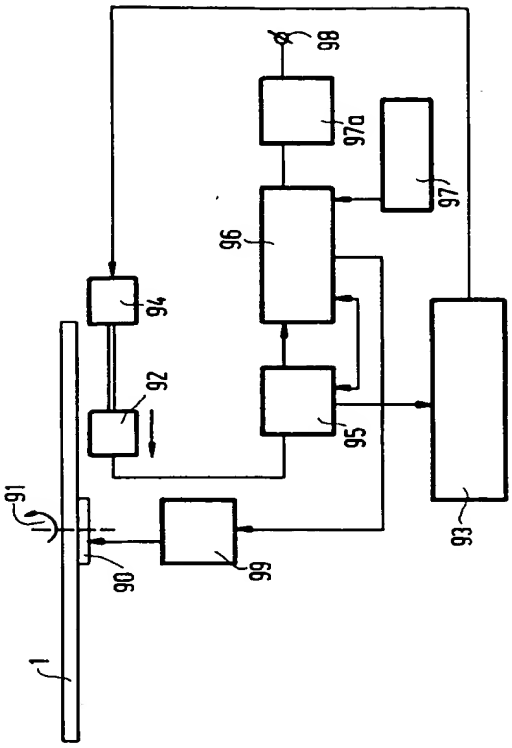

FIG.9

The invention relates to an information recording device for recording time-synchronous information pieces, particularly audio information pieces which are applied as continuous and time-synchronous information streams to an input of the recording device at arbitrary intervals, said recording device comprising search means for searching given portions of a track on the record carrier, scanning means for scanning the searched track portion by means of a write head for providing information patterns in the track, said write head being coupled to the input in order to provide an information pattern representing the supplied information stream in the scanned track portion, control means adapted to realise a search operation, prior to providing the information pattern, of an intermediate portion in the track released for recording, said intermediate portion being located between track portions in which the presence of an information pattern which is already present is to be maintained, said control means being further adapted to provide an information pattern representing the supplied information stream in the searched intermediate portion.

The invention also relates to a record carrier comprising a track in which information patterns are provided which represent time-synchronous information pieces, particularly audio information pieces.

The invention also relates to an information reading device which comprises search means for searching given portions of the track on the record carrier, a read head for scanning the information patterns in the searched track portions and for supplying an information stream corresponding to the scanned information patterns, an output for supplying continuous and time-synchronous information streams, said output being coupled to an output of a signal processing circuit.

Such a recording device, reading device and record carrier are known from EP-A-0 275 972. This Application describes a magneto-optical recording device for recording digitized audio information on a reinscribable record carrier in the form of a magneto-optical disc. A table of contents is recorded on the record carrier, which table indicates the start and end addresses of the track portions in which the information patterns for the relevant information pieces, in this case pieces of music, are provided. If the recording of a given piece of music is no longer desired, the address data for the relevant piece of music are removed from the table of contents. The track portions of the relevant piece of music are then released for recording further pieces of music. The recording device is adapted to visualize, if desired, the lengths of the released track portions on a display unit. The user may use this information for selecting the location where another piece of music can be recorded. The user should select a released track portion which is sufficiently long for recording the piece of music. Since the length of the selected track portion will always be larger in practice than the required length, a small part of the released track portion will be left after recording. This small part will often be too small for recording further pieces of music, resulting in a poor utilization of the storage capacity of the record carrier. Moreover, when a piece of music is being recorded, the length of the piece of music cannot always be determined in advance so that, when selecting the track portion released for recording, there is a real risk that the selected intermediate portion appears to be not long enough.

It is, *inter alia*, an object of the invention to provide a recording device in which released track portions are selected in a more convenient way.

This object is achieved by a recording device as described in the opening paragraph, which is characterized in that the device comprises an input buffer which is coupled to the input for receiving the information stream, and an output which is coupled to an input of the write head for supplying the information stream to be recorded, the device being provided with means for detecting, during scanning of the intermediate portion, when a position in the intermediate portion located proximate to the end of the intermediate portion is reached, means for interrupting, in response to the detection, the provision of the information pattern and for interrupting the information stream from the input buffer to the write head, and means for realising, in response to the detection, a search of a further track portion released for recording, for resuming the supply of information from the input buffer and for resuming the provision of the information pattern, the storage capacity of the input buffer being sufficient to store the presented information stream when the next released portion is being searched, the device being further provided with means for storing information indicating in which track portions the information patterns representing the individual information pieces are provided.

Due to the use of the input buffer there need not be any fixed time relation between the information stream received at the input and the information stream supplied to the processing circuit. This provides the possibility of temporarily interrupting the recording operation, while the continuous reception of a time-synchronous information piece can be maintained. This renders it possible, at the end of a released intermediate portion, to make a jump to a subsequent released intermediate portion or to the still unused portion at the end of the track. This means that the released intermediate portions can be much better utilized.

Moreover, the selection of the released intermediate portion upon recording a new piece of information is considerably simpler, because any released intermediate portion is principally suitable.

The information thus recorded can be read by means of a reading device as described in the opening paragraph which is characterized in that the device comprises an output buffer having an input which is coupled to an output of the read head, an output of the output buffer being coupled to the output of the device, the device being provided with means for interrupting the information streams to the output buffer on the basis of the control information recorded on the record carrier and for displacing the scanning to another track portion in which information patterns of a subsequent portion of the information piece to be read are provided after an end of a track portion with information patterns of the information piece has been reached.

Due to the use of the output buffer there need not be a fixed time relation between the information stream from the signal processing circuit to the output buffer and the information stream from the output of the output buffer to the output of the device. This provides the possibility of making track jumps without this being at the expense of the continuous and time-synchronous supply of an information piece at the output of the reading device.

In this connection it is to be noted that the decoupling of information streams in recording and reading devices is known *per se* from EP-A-0 429 139. In the recording and reading device described in this Application the decoupling has for its object to enable information to be recorded at a faster rate than at the rate at which the information is supplied in order that the use of the tracking and focusing servosystem can be continued with an optimum adjustment. The information patterns representing the information pieces are not spread over a number of different intermediate portions in this recording device.

However, the invention is eminently suitable for use in combination with the last-mentioned device, because the provisions rendering the decoupling operation possible can then be used for a dual purpose so that the device is used efficiently.

Further embodiments and their advantages will hereinafter be described in detail with reference to Figs. 1 to 15 in which

Fig. 1 shows an embodiment of a record carrier according to the invention,

Fig. 2 shows an embodiment of a recording device according to the invention,

Figs. 3, 4 and 5 show examples of tables of contents,

Fig. 6 shows a flow chart of a program for controlling the recording operation,

Figs. 7 and 8 illustrate the variation of the filling level of the input buffer as a function of time,

Fig. 9 shows an embodiment of the reading device according to the invention,

Fig. 10 shows a flow chart of a program for controlling the reading operation,

Fig. 11 shows an embodiment of a combined recording and reading system according to the invention,

Figs. 12 and 14 show flow charts of control programs performed by control units in recording and reading systems according to the invention,

Fig. 13 is a plan view of a record carrier to illustrate the invention and

Figs. 15a and 15b show adaptations of the system shown in Fig. 12.

Fig. 1 shows diagrammatically an embodiment of a record carrier 1 of a reinscribable type, for example, an optical, magneto-optical or magnetic type. The record carrier 1 shown is disc-shaped, but in principle the invention is also applicable to other record carrier shapes such as, for example tape-shaped record carriers. However, the invention will be described in greater detail with reference to disc-shaped record carriers. The record carrier 1 comprises a spiral track 2 in which information patterns are or can be recorded. The information patterns represent time-synchronous information. Time-synchronous information is understood to mean information which becomes available synchronously with time and is to be reproduced synchronously with time. Such time-synchronous information may be audio information or video information. The track 2 of the record carrier shown accommodates the information patterns for three information pieces, *viz.* a first information piece in the track portion between points 3 and 4, a second information piece between points 4 and 5 and a third information piece between points 5 and 6. The track 2 further comprises a track portion released for recording, which portion is located between point 6 and the end point 7 of the track. The term track portion is hereinafter understood to mean an uninterrupted portion of the track which comprises only information patterns of one and the same information piece or which is released in its entirety.

The record carrier 1 also comprises contents information indicating the start and end addresses of the track portions in which the information pieces are recorded. This contents information may be incorporated, for example in a table of contents which is recorded on a portion of the track intended for this purpose. Such a portion may be located, for example at the beginning of the track

2, between the points 8 and 3. If the start and end addresses are indicated by an absolute time code, as is common practice with Compact Disc signals, Fig. 3 shows an example of a suitable table of contents. The table of contents comprises the start addresses BA and the end addresses EA of the track portions in which information is recorded and which are not released for recording new information. Column TNO states with which information piece the information in the relevant track portions is associated. Column p denotes the number of track portions used for recording the relevant information piece. Column g states the sequential number of the track portion within the series of successive track portions in which the relevant information piece is recorded. Column BA comprises the start addresses, expressed in absolute time codes, of the recorded information pieces, while column EA indicates the end addresses of the relevant track portion. If the recording of one of the information pieces, for example, the second information piece in the table of Fig. 3 is no longer necessary, the address information of the track portions in which the relevant information piece is recorded can be removed from the recorded table as is shown in Fig. 4. The track portion originally occupied by the second information piece (also referred to as intermediate portion) may be used for recording a new information piece.

In the recording method according to the invention the information of an information piece is spread over a number of non-adjacent track portions. This is particularly advantageous if no track portion available for recording is available on the record carrier, which portion is long enough to record the complete information piece. In that case the method according to the invention provides the possibility of spreading the information over two or more non-adjacent track portions.

Moreover, the manner of recording is very convenient. In fact, the disc player determines which released track portions are used for recording. Thus, the user need no longer select a released track himself.

An embodiment of the invention with which this can be realised is shown in Fig. 2. The recording device comprises a read/write head 24 of a conventional type. To obtain a scanning of the tracks of the record carrier 1, the record carrier 1 is moved along the read/write head 24 by means of a drive motor 22 which rotates the record carrier around a shaft 23. The radial position of the scanning is then conventionally controlled in such a way that the point of scanning is substantially held on the track of the record carrier. The address of the scanned track portion is determined by a control unit 26 in a conventional manner, for example, on the basis of read signals supplied by the read/write head 24. For searching desired track portions, the device is provided with a displacement mechanism 25 for radially displacing the point of scanning under the control of the control unit 26. The recording device has an input 27 for receiving time-synchronous information pieces which are intermittently applied to the input 27. The time-synchronous information received at the input 27 is arranged in accordance with a suitable format by means of a signal processing circuit 28. The information thus arranged is converted by a control circuit 32 into a suitable write signal for the read/write head 24, which in response to the write signal provides an information pattern in the track of the record carrier, which pattern represents the information supplied. An input buffer 29 is arranged between the input 27 and the control circuit 32. The input buffer 29 is of a conventional type in which supplied information can be temporarily stored before this information is supplied again and in which information can be stored at a rate which is independent of the rate at which the stored information is supplied. Such an input buffer may be a FIFO buffer in which the storage and supply of information is controlled by means of two clock signals cli and clo which are independent of each other. In the embodiment shown the recording device comprises a clock signal generator 31 for generating the clock signals cli and clo for controlling the storage and supply, respectively, of information in/by the input buffer 29.

In the embodiment of Fig. 2 the information is first applied to the signal processing circuit 28 and subsequently to the input buffer 29. However, the input buffer 29 and signal processing circuit 28 may be arranged in the reverse order. The control unit 26 may be of a programmable type which is loaded with a suitable control program for controlling the recording. Fig. 6 shows a flow chart of a suitable control program. A control program is called, for example in response to a recording assignment which is applied by the user to the control unit 26 *via* an operating panel. The program comprises a step S1 in which a track portion released for recording is selected on the basis of the table of contents. If the contents of the table of contents correspond to the contents of the Table shown in Fig. 4, the track portion which is located between addresses 22'.39".15 and 45'.06".10 and the track portion beyond address 58'.12".43 will be suitable for the recording operation. Prior to the recording operation it should be determined in which one of the available track portions the recording operation will start. It will be evident that various selection procedures are possible for this purpose, with which procedures a selection is made from the available released track portions in dependence or not in dependence upon the length

of the information piece to be recorded. In the embodment described hereinbefore the first released track portion is selected each time. To prevent an information piece from being recorded in very small track portions, it is, however, preferable to disregard track portions which are smaller than a given length, for example a length corresponding to 30 seconds of the information piece.

In step S2 the start of the track position is searched by means of the address 22'.39".16 which indicates the start of the selected released track portion. Subsequently, the recording operation is started while performing step S3. Step S3 is followed by step S4 in which it is checked whether the recording operation of the new information piece to be recorded must be terminated. If not, step S5 is subsequently performed in which it is checked whether the end of the track portion released for recording and indicated by address 45'.06".09 is reached. If negative, the program is continued with step S4. If positive, step S6 is performed. When step S6 is being performed, the recording operation is interrupted. This means that the supply of the information present in the input buffer 29 is interrupted and that the read/write head 24 is brought, *via* the control circuit 32, to a state in which no information patterns are provided. It is preferred to provide a distinguishable control pattern at the end of the recorded information, which pattern indicates this end. This has the advantage that the last portion of the information piece provided in the relevant track portion can be simply and accurately determined during the reading operation.

The quantity of information in the input buffer 29 will increase due to the interruption of the supply of information from the input buffer 29, because the supply of information to be recorded is continued at the input 27. For the purpose of illustration Fig. 7 shows the filling level VG (here defined as the ratio between the quantity of information stored in the buffer, divided by the total storage capacity) of the input buffer 29 as a function of time t. The instant t1 indicates the instant when the supply of information by the input buffer is interrupted during the execution of step S6. After the execution of step S6, step S7 is performed in which the start of a subsequent track portion released for recording is searched. In this example this is the track portion having the address 58'.12".44. As soon as this track portion has been found, step S3 is performed again, in which step the recording operation is resumed. It is preferred to incorporate a distinguishable control pattern at the start of the recorded information, which pattern indicates this start. When the information is being read, the start of the portion of the information piece in the relevant track portion can then be determined simply and accurately. The use of control patterns indicating the start and the end of the information recorded in the track portion considerably facilitates the combination of the information from the different track portions during the reading operation.

In Fig. 7 the instant of resuming the recording operation is denoted by t2. At this instant the supply of information from the input buffer is resumed and the filling level VG of the input buffer will not increase any further.

As soon as it is ascertained during the execution of step S4 that the recording operation can be ended, step S8 is performed. When this step is performed, the storage of information in the input buffer 29 is discontinued. The supply of information by the input buffer may continue until the input buffer is completely empty. Furthermore, the read/write head 24 is controlled in a state in which information patterns are no longer provided. In Fig. 7 the instant when the storage of information in the input buffer is discontinued is indicated by the instant t3. The instant when the supply of information by the input buffer is discontinued is denoted by t4. In step S9 the table of contents is adapted to the address information indicating the start and end addresses of the track portions in which the information patterns of the information piece to be recorded are provided. Fig. 5 shows the table of contents for the example described. It will be evident to those skilled in the art that the way in which the address information is incorporated in the table of contents can be realised in numerous other ways than is shown in Fig. 5. It is further to be noted that the links between the different track portions may also be indicated in a manner other than with a table of contents. For example, if a sub-code is added to the recorded information during recording of the information piece it is possible to incorporate said link between the track portions in the sub-code of the information recorded in the track portion.

Once again it is to be noted that it is preferred to release only track portions which exceed a given minimum length, for example a length which is sufficient to record information having a length of 30 seconds. It is thereby prevented that an information piece must be spread over a very large number of track portions and recorded, resulting in the information about the links between the track portions used becoming very extensive. Moreover, due to the restriction that the track portions used for recording should have a minimum length it is achieved that after making a jump to a subsequent track portion there is sufficient time to empty the input buffer to a sufficient extent before a new jump must be made to a subsequent released track portion.

It is alternatively possible to impose a maximum, for example, 5 on the number of track portions used for recording an information piece.

The information about the addresses of the track portions used for recording the information pieces is preferably recorded on the record carrier itself. However, if the recording device is provided with a non-exchangeable record carrier, this information may alternatively be recorded in a non-volatile memory of the recording device itself.

In the example described hereinbefore the rate at which the information is supplied by the input buffer is equal to the rate at which the information is loaded into the buffer. This means that the filling level of the input buffer will increase at each jump to a subsequent track portion released for recording. All this means that the number of jumps to a subsequent released track portion is limited. This drawback can be obviated by rendering the rate of supply and the recording rate dependent on the filling level of the input buffer. For example, it is possible to temporarily increase the supply and recording rates at a high filling level until a given filling level is reached. Moreover, to prevent the buffer from getting empty, the supply and recording rates can be chosen to be lower than the storage rate at a filling level below a given value.

Fig. 8 shows the variation of the filling level VG as a function of time for the case where the supply rate is controlled in accorance with the principle described hereinbefore. The instant of starting the recording operation is denoted by t5. At this instant the loading of information into the input buffer 29 is initiated. Moreover, the supply of information is started at a lower rate than the load rate of the information. This means that the filling level increases. At the instant t6 the filling level VG exceeds a threshold D. In response to this level exceeding the threshold the supply rate is rendered equal to the load rate so that the filling level of the input buffer remains constant. At the instant t7 the end of a track portion used for recording is reached and a jump is made to the start of a subsequent released track portion, resulting in the supply of information from the input buffer being interrupted. The filling level VG will now increase. At the instant t8 the recording operation in the newly searched track portion is initiated. Since the filling level of the input buffer is above the threshold D, the supply rate is increased to a value which is larger than the load rate in order that a decrease of the filling level VG is then obtained. At instant t9 the threshold value D is reached and the supply rate is rendered equal to the load rate again. The filling level VG now remains constant. At instant t10 the supply of information to the input buffer 29 is ended. The filling level will now decrease until the buffer is entirely empty at the instant t10 and the supply and recording operations are terminated.

Fig. 9 shows an embodiment of a reading device for reading the information pieces on record carrier 1. The reading device comprises a motor 90 for rotating the record carrier 1 around a shaft 91. A read head 92 of a conventional type for scanning the track 2 on the record carrier 1 is arranged opposite the rotating record carrier 1. For searching desired track portions, the point of scanning can be radially displaced across the record carrier by means a displacing mechanism 94 under the control of a control unit 93. During scanning of the track the read head supplies a read signal which represents the scanned information pattern in the track 2. The read signal is applied to a signal processing circuit 95 which regains a data clock signal and the recorded information from the read signal. The regained information is applied to an input of an output buffer 96. The regained data clock signal is also applied to a clock input of the output buffer 96 to control the loading of the output buffer 96 with the supplied information at a rate which is fixed by the frequency of the data clock signal. The output buffer 96 is of a type in which information can be loaded at a rate which is independent of the rate at which the information is supplied by the output buffer 96. Since the recorded information pieces relate to time-synchronous information, the rate at which the information is supplied by the output buffer should be very constant. This is realised by controlling the supply of information with a clock signal of a very constant frequency which is supplied by a clock signal generator 97. The information supplied by the output buffer 96 is applied to an output 98 of the reading device *via* an output stage 97a. The output buffer 96 is of a conventional type which supplies a signal which is indicative of the filling level of the output buffer 96. This signal is applied to a motor drive circuit 99 which controls the number of revolutions of the motor in such a way that the filling level of the output buffer is controlled to a given reference value. The reading operation is controlled by the control unit 93 which is provided with a suitable control program for this purpose. A flow chart of a possible example of such a control program is shown in Fig. 10. This program starts with step S10. During the execution of this step the table of contents is read and subsequently a waiting time is observed for a read command for a given information piece which can be selected by the user *via* an operating panel. After the read command has been given, the start of the first track portion used for recording the selected information piece is searched during the execution of step S11 on the basis of the information read from the table of contents. As soon as the start of the portion of the information piece recorded in the

searched track portion is detected, the information reading operation and the operation of storing this information in the output buffer 96 are started during the execution of S11. Furthermore, the supply of information from the output buffer 96 to the output 98 is initiated. Subsequently it is checked in step S12 whether the end of the recorded information piece has been reached. This may be effected, for example, on the basis of the information incorporated in the table of contents. However, it is alternatively possible that a sub-code indicating the end is added to the recorded information. In that case the end can be detected on the basis of the sub-code which has been read. If during the execution the end of the information is detected, step S13 is performed in which the reading operation is terminated. However, if the end of the information piece has not yet been detected, step S12 is followed by step S14. When performing this step, it is checked whether the end of a track portion, not being the end of the information piece, has been reached. This check can be performed on the basis of the information in the table of contents. However, if control patterns indicating the end are incorporated at the end of the recorded information, the check is preferably performed on the basis of these control patterns. If it is ascertained during the execution of step S14 that the end of the track portion has not been reached, step S14 is followed by step S12. However, if it has been ascertained that the end of this track portion has been reached, step S15 is performed. When performing step S15 the reading of information and the storage of information in the output buffer 96 are interrupted, while the supply of information from the output buffer 96 is maintained. Subsequently step S16 is performed in which the start of the next track portion is searched in which information patterns for the relevant information piece have been recorded. This searching operation is carried out on the basis of the start addresses of the track portions. As soon as the desired track portion has been searched, the start of the recorded information is detected, preferably on the basis of control patterns which are provided at the start of the recorded information. As soon as the start of the recorded information has been found, the reading and loading operations of the output buffer 96 are resumed. Subsequently step S12 is performed again. During interruption of the information reading and loading operations the filling level of the output buffer will decrease. After the reading and loading operations of the output buffer have been resumed, the number of revolutions of the motor 90 will increase as a result of the decreased filling level. Consequently, the read and load rates increase so that the filling level will increase to the desired level again. This level should be chosen in such a way that sufficient information is available in the output buffer during the search of the next track portion so as to guarantee an uninterrupted supply of information to the output. The time required for searching a subsequent track portion is less than 1 second in conventional reading devices. This time determines the required storage capacity of the output buffer and the desired extent of the filling level. Due to the restriction that the track portions used for recording should have a minimum length, it is also achieved that there is sufficient time available for filling the output buffer 96 to its filling level after a jump has been made to a subsequent track portion.

Fig. 11 shows a further embodiment of a combined recording and reading system according to the invention. The device comprises a motor 101 for rotating a disc-shaped optical record carrier 102 about its shaft, which carrier is of a reinscribable type and has a spiral track. A read/write head 103 with which a track on the record carrier 102 is scanned by a radiation beam for reading and recording information is arranged opposite the rotating record carrier 102. The system is provided with a tracking system of a conventional type (not shown) which ensures that the centre of a scanning spot produced by the radiation beam on the record carrier substantially coincides with the centre of the track. Furthermore the device is provided with a focus control (likewise not shown) for keeping the scanning beam focused on the record carrier, a scanning rate control system of a conventional type (not shown) for controlling the rate at which the record carrier 102 is moved along the read/write head 103. The read/write head 103 can be displaced radially with respect to the record carrier 102 by means of a radial displacing mechanism 104.

The recording and reading system further comprises a circuit 105 for digitizing a time-synchronous audio or video signal Va. Such a circuit may comprise, for example a clock-controlled A/D converter. In addition to the A/D converter, the circuit 105 for digitizing the analog signal may also comprise a digital processing circuit for compressing the digital signal supplied at the output of the A/D converter. It is neither necessary that the information to be recorded is presented in an analog form. This information may equally well be presented in a digital form and converted by a digital processing circuit such as, for example, a standard digital audio interface circuit, before being recorded. When the A/D converter is used, the bit frequency of the digitized signal Va' is dependent on the desired quality of the digitized signal which is determined, *inter alia*, by the number of bits per signal sample and the sampling frequency. However, the use of data compression techniques may

decrease the bit frequency without any noticeable loss of quality. An input buffer of a type as already described hereinbefore is denoted by reference numeral 106. The input buffer 106 is arranged between the circuit 105 and the control circuit 107 for supplying a write signal to the read/write head 103. The input buffer 106 is loaded at a rate which corresponds to the bit frequency of the digitized signal Va' at the output of the circuit 105. The information stored in the input buffer 106 is retrieved and subsequently applied to a data input of the control circuit 107 at a retrieval rate which is related to the scanning rate during the recording operation.

For the control of the circuit 105 and the control of the loading of input buffer 106, the device is provided with a clock signal generator 108 for supplying a clock signal cl1 for the circuit 105 and a clock signal cl2 for the input buffer 106, which signal is related to the clock signal cl1.

A second clock signal generator 109 applies a retrieval clock signal cl3 to the input buffer 106 for retrieving the information stored in the input buffer 106, the retrieval clock signal cl3 having a frequency which is related to the scanning rate during the recording operation. The recording control may be performed in such a way that, as soon as the filling level of the input buffer exceeds a given upper limit, an information retrieval and recording procedure is performed in which the information stored in the input buffer 106 is retrieved and is subsequently recorded. Retrieval and recording of information is postponed until the filling level has come below a given lower limit, whereafter the retrieval and recording process is discontinued until the filling level has exceeded the upper limit again. For such a control the system is provided with control unit 110, for example of a programmable type. The control unit 110 is coupled to the radial displacing system 104 for realising, by means of applying a control signal, a scanning jump in the radial direction to a given portion of the track which is indicated by a desired destination address. Furthermore, the control unit 110 is coupled to the clock signal generators 108 and 109 for activating and deactivating the supply of the clock signals supplied by the generators 108 and 109. The control unit 110 also applies a control signal to the control circuit 107. The control circuit 107 is formed in such a way that, dependent on the received control signal, the read/write head 103 can be set to either the read mode or the write mode. In the read mode the read/write head 103 supplies a read signal VI which represents the information recorded at the location of the scanning in the track portion scanned by the read/write head 103. In the write mode a recording of the information received at the data inputs of the control circuit 107 is realised by means of the read/write head 103. For controlling the recording and the control unit 110, the input buffer 106 also supplies an indication signal Vg1 which is indicative of the filling level of the input buffer 106. Moreover, an output signal of the input buffer 106 representing the retrieved information is applied to the control unit 110. Finally, the read/write head 103 is coupled to the control unit 110 for supplying the read signal VI to the control unit 110.

The recording control will hereinafter be explained with reference to Fig. 12 showing a flow chart of a suitable control program and Fig. 13 which is a plan view of the record carrier 102.

The program whose flow chart is shown in Fig. 12 comprises a step S101 which is performed if a recording of the analog information applied to the circuit 105 is desired. During the execution of step S101 the control unit 110 moves the read/write head 103 to the start of the track 2 in which the table of contents is recorded and the table of contents is read. Based on the table of contents which has been read, the track portions released for recording are determined, in which portions the supplied information should be recorded. Finally, the first released track portion selected for recording is searched during the execution of step S101. Subsequently, the circuit 105 is activated by activating the generation of the clock signal cl1 during the execution of step S102. It is to be noted that it is not necessary for the activation of the circuit 105 to be started after the read/write head 103 has reached the desired position. This may also take place prior to searching the desired position. The digitized information at the output of circuit 105 is loaded into the input buffer 106, synchronously with the loading clock signal cl2. After the execution of step S102 it is ascertained, during the execution of step S103, with reference to the indication signal Vg1 whether the filling level of the input buffer 106 has exceeded a given value Vmax. As soon as the filling level has exceeded this value it is checked in step S104 whether the information stored in the input buffer 106 relates to the first packet of information to be recorded. If positive, the point on the track where the recording can start is searched during the execution of step S104a, which is effected in a way as described, for example, in European Patent Application EP-A-0 325 329 (PHQ 88.002). Subsequently, the recording operation is started during the execution of step S105. When step S105 is performed, the generation of the retrieval clock signal cl3 is activated so that the information stored in the input buffer 106 is applied to the control circuit 107 synchronously with the retrieval clock signal cl3. During the execution of step S105 the read/write head 103 is also set to its write mode resulting in the informa-

tion applied to the control circuit being recorded. For the purpose of illustration reference numeral 130 in Fig. 13 indicates the point where the recording operation starts in a spiral track 131. After execution of step S105 it is checked during the execution of step S113 whether the end of the track portion released for recording has been reached. If negative, step S105 is followed by step S106.

The rate at which the information is retrieved from the input buffer 106 is higher than the rate at which the input buffer 106 is loaded so that the filling level of the input buffer 106 will decrease during the recording operation. In step S106 it is checked whether the filling level of the input buffer 106 comes below a given limit Vmin. If positive, the point in the track where the recording operation will be interrupted is determined during the step S107. Moreover, information indicating this point is stored, for example in the memory of the microcomputer 110. If the recorded information comprises address information, the point where the recording operation must be interrupted can be coarsely fixed by means of an address comprised by the information. The exact position of the interruption can be indicated by a synchronization code which is recorded at a predetermined point with respect to the point of interruption. This synchronization code may consist of a code which is distinguishable from the information and which is specially added to the recording information for this purpose. If the information to be recorded already comprises synchronization codes such as, for example the EFM synchronizing signals or the subcode synchronizing signals in a standard CD signal, these codes are preferably used to indicate the exact position of interruption of the recording operation. This may be realised, for example, by interrupting the recording operation at a fixed instant after recording the next synchronization code and after the filling level has come below the limit value Vmin. The actual interruption of the recording operation is realised in step S108. In this step the read/write head 103 is set to its read mode at the instant when the position has been reached where the recording operation must be interrupted, and simultaneously the supply of information from the input buffer 106 is interrupted by deactivating the generation of the retrieval clock signal cl3. In Fig. 13 the point at which the recording in the track 131 is interrupted is denoted by the reference numeral 132. After the execution of step S108 it is ascertained during step S109 whether all packets of information have already been recorded. If negative, step S110 is performed in which a jump of the read/write head across one or more tracks is realised towards a turn of the spiral track which precedes the track portion in which the recording has been interrupted. The jump is denoted by arrow 133 in Fig. 13. As a result of the radial jump a track portion is scanned which is located before the point 132 where the recording was interrupted. During the execution of step S111 it is checked with reference to the read signal VI whether point 132 has been reached again. This may be effected, for example, by comparing the address information obtained during reading with the stored address which roughly indicates the position where the recording was interrupted. Subsequently the exact position of the interruption can be determined by detecting the next synchronization code in the read signal VI after conformity between said addresses has been ascertained. After detection of the exact position of the interruption the recording operation is resumed by performing step S105. It is to be noted that the instant of resuming may alternatively be determined in dependence upon the filling level instead of in the manner as described hereinbefore. For example, it is possible to observe a waiting time for the resumption of the recording operation until the filling level of the input buffer 106 has exceeded a given maximum value and to subsequently search the point where the recording operation was interrupted. When the entire signal is being recorded, the recording operation is each time interrupted temporarily in the positions in the track 131 denoted by the reference numerals 133, ..., 136. This process of interrupting and resuming the recording operation continues until in step S109 the last packet of the information to be recorded is detected and step S112 is performed. During the execution of step S112 the digitization of the information applied to the A/D converter 105 and the loading of the digitized information in the input buffer 106 is discontinued by deactivating the loading clock signal cl2 and the clock signal cl1. It is to be noted that, in general, the input buffer 106 is then not completely empty. This is not a problem when recording audio signals because only a very short signal portion is concerned. However, if recording of the complete audio signal is desired, the contents of the input buffer may be supplemented with a signal which represents silence and the point at which the recording operation is terminated may be chosen to be such that the stopping instant occurs while the signal representing this silence is being recorded.

If it is detected during the execution of step S113 that the end (denoted by point 137 in Fig. 13) of the track portion released for recording has been reached, step S114 is carried out. In step 114 the point where the recording must be discontinued is determined on the basis of the information, present in the player, about the instantaneous position of the scanning spot and the end point of the released track portion. In step S115 the actual interruption of

the recording operation is realised. The recording operation is preferably terminated at the end of the track portion with the recording of an end pattern which is unique for the code and indicates the end of the information recorded in the relevant track portion. This end pattern may be used for detecting the end of the portion of the information piece in the relevant track portion when the track is being read at the decoder level at a later stage. Similarly as in the execution of step S108 the read/write head 103 is set to its read mode and the supply of information from the input buffer 106 is interrupted. Subsequently a jump is made during the execution of step S116 to a point (denoted by point 138 in Fig. 13) which is located before the start of the next track portion released for recording. In the execution of step S117 it is detected, on the basis of the address which has been read, whether the start of this released track portion has been reached. Subsequently the recording operation is resumed by continuing the program with step S105. The recording operation preferably starts by providing a unique starting pattern which directly precedes the recording of the information patterns representing the information piece to be recorded. This unique starting pattern provides the possibility of simply and accurately determining, during the reading operation, the start of the part incorporated in the relevant track portion of the information piece to be read.

It is further to be noted that when checking in step S113 whether a jump must be made to a subsequent (non-contiguous) track portion, a track jump has just been performed within the track portion being instantaneously in use (during the execution of the steps S110, S104 and S111). This means that the input buffer 106 is already filled at the start of the jump to the next track portion. It is necessary that the capacity of the input buffer is sufficiently large to store the synchronous information received *via* the input during the entire period of the jump to the next track portion.

The required storage capacity of the input buffer may be reduced as follows. Based on the instantaneous filling level of the input buffer 106, the instantaneous recording address and the end address of the track portion, the instant when the last track jump is to be performed within the track portion being instantaneously in use can be determined in order that the input buffer 106 is substantially empty at the start of the jump to the next track portion.

The recorded information can be read by scanning the track in which the information has been recorded by means of the read/write head 103 which must be set to the read mode for this purpose. The read/write head 103 supplies the read signal VI which can be loaded into an output buffer 111 synchronously with a load clock signal cl4 generated by the clock signal generator 109. The information loaded into the output buffer 111 is retrieved synchronously with a retrieval clock signal cl5 generated by the clock signal generator 108. The retrieved information is applied to a D/A converter 112 which is controlled by a clock signal cl6 which is also generated by the clock signal generator 108. Recorded information in an analog form is supplied at the output of the D/A converter 112. The frequency of the load clock signal cl4 is chosen to be such that the rate at which the output buffer 111 is loaded corresponds to the scanning rate during reading of the information. The frequencies of the clock signals cl5 and cl6 are chosen to be such that the rate at which the analog information is supplied at the output of the D/A converter 112 corresponds to the rate at which this information is received by the A/D converter 105 so that a high fidelity reproduction of the recording information is obtained during reading. The information is being read under the control of the control unit 110 which is loaded with a suitable program for this purpose.

Fig. 14 shows a flow chart for an example of a suitable program. This program comprises a step S120 in which, under the control of the control unit 110, the read/write head 103 is put opposite the track portion in which the information to be read has been recorded. Subsequently the reading operation is started in step S122 by activating the supply of the clock signals cl4, cl5 and cl6. As a result of the activation of the clock signal generation, the information read is loaded into the output buffer 111 at a rate which corresponds to the read rate. The stored information is retrieved from the output buffer 111 synchronously and at a lower rate than the loading rate and subsequently converted into an analog form by the D/A converter 112. Step S122 is followed by step S131 in which it is checked whether the end of the track portion has been reached in which a part, not the last part of the information piece has been recorded. If this end is not reached, the program continues with step S123. When performing this step the filling level which is indicated by an indication signal Vg2 generated by the output buffer 111 is compared with a maximum value Vmax2. As soon as the filling level exceeds this maximum value, step S124 is carried out in which the position is determined where the storage of the information which has been read can be interrupted. This may be realised similarly as determining the interruption during recording with reference to the address information indicating the point of scanning and the synchronization codes incorporated in the recorded information. When this position is reached, the reading of information and the storage of informa-

tion in the output buffer 111 is stopped during the execution of step S125 by deactivating the generation of the clock signals cl4. In step S126 a radial scanning jump is subsequently made towards a turn of the spiral track preceding the point where the reading operation was interrupted.

In step S127 it is subsequently checked whether all packets of the desired information have been read in their entirety. If negative, it is determined, during the execution of step S128, and on the basis of, for example the address information and the synchronization code incorporated in the signal which has been read whether the point where the reading operation was interrupted is reached again. As soon as this point has been reached, the loading of the output buffer 111 is resumed in step S129 by activating the clock signal cl4. After the execution of step S129, step S131 is performed again. If it is ascertained in step S131 that the end of the track portion has not yet been reached, step S123 is carried out again. During read-out of the series of steps S123, S124 and S125 the information which has been read is interrupted again as soon as the filling level of the output buffer 111 exceeds the value Vmax2 again.

This process of each time temporarily interrupting the storage of information which has been read is continued until it is ascertained during the execution of step S127 that all desired information has been read, whereafter step S130 is carried out in which the retrieval of the information from the output buffer 111 is interrupted by deactivating the generation of the clock signals cl5 and cl6 as soon as the output buffer is empty.

If it has been ascertained during the execution of step S131 that the end of a track portion in which a part, not being the last part, of an information signal is approached, step S132 is carried out.

During the execution of step S132 it is checked whether the position has been reached where the storage of read information in the output buffer 111 must be interrupted, preferably on the basis of the end pattern provided. When this position is reached, step S133 is performed in which, similarly as in step S125, the storage of information in the output buffer 111 is discontinued. Subsequently step S134 is performed, making a jump to a point on the track which is located before the start of the next track portion where the next part of the information piece to be read is recorded. Subsequently the start of the information pattern provided in the searched track portion is detected during the execution of step S135. This is preferably realised on the basis of the start pattern provided at the start of the track portion. In response to a detection of this start pattern, the loading of information in the output buffer 111 is resumed during the execution of step S136.

Subsequently the program is continued with step S123.

It is to be noted that the output buffer will no longer be completely full if step S131 is preceded by step S129. This results from the fact that the loading of output buffer 111 was interrupted when the jump was being made during the execution of step S126. It is important that at the instant when it is ascertained in step S131 that the end of a track portion is reached, the output buffer 111 is still sufficiently filled to be able to supply information from the buffer 111 to the output of the reading device during the period of the jump to the next track portion where the further information of the information piece is recorded. This means that the capacity of the output buffer 111 should be chosen to be sufficiently large.

The required capacity of the output buffer may be reduced as follows. Based on the instantaneous filling level of the output buffer, the address of the instantaneous recording and the end address of the available track portion, the instant can be determined at which the last track jump within the track portion being instantaneously in use is to be performed in order that the output buffer is substantially entirely filled at the start of a jump to the next (non-contiguous) track portion.

Figs. 15a and 15b show possible adaptations of the embodiment of Fig. 11 for the case where the digitized information to be recorded undergoes an additional modulation treatment. These Figures only show that part of the system which is modified with respect to the system shown in Fig. 11. In Fig. 15a these modifications relate to a modulation circuit 150 for modulating the information retrieved from the input buffer 106. The modulation circuit 150 is to be switched off or switched on simultaneously with the interruption and resumption, respectively, of loading the input buffer 106. This can be realised in a simple manner, for example, by using a clock-controlled modulator which is controlled synchronously with the load clock signal cl3. By way of alternative, Fig. 15a shows a digital data compression circuit 105a which is arranged between the circuit 105 and the input buffer 106.

The modifications in Fig. 15b relate to a demodulation circuit 151 for demodulating the information read before it is applied to the output buffer 111. The demodulation circuit 151 should be switched off or switched on simultaneously with the interruption and resumption, respectively, of loading the output buffer 111. This may be realised in a simple manner, for example, by using a clock-controlled demodulator which is controlled synchronously with the load clock signal. By way of alternative, Fig. 15b shows a digital data decompression circuit 112a which is arranged between

the output buffer 111 and the D/A converter 112.

The invention has been described hereinbefore with reference to a recording and reading system for rotating disc-shaped record carriers. However, it is to be noted that the use of the invention is not limited to recording and reading systems of rotating disc-shaped record carriers. In principle, the invention may be used in any recording and reading system in which it is possible to realise a scanning to a different portion of the track. The use of the invention is neither limited to optical or magneto-optical recording and reading systems but may also be used in magnetic recording and reading systems.

It is further to be noted that the decision criteria based on which the recording and/or reading operations are interrupted and resumed are not limited to the decision criteria described. For example, it is possible to interrupt the recording and/or reading operations after reading or recording information from/on an integral number of turns of the spiral track. It is, for example, also possible to resume the recording and/or reading operation only after a minimum time interval has elapsed. It is always essential that the storage capacity is chosen to be sufficiently large to compensate for the fluctuations occurring in the quantity of stored information.

Claims

1. An information recording device for recording time-synchronous information pieces, particularly audio information pieces which are applied as continuous and time-synchronous information streams to an input of the recording device at arbitrary intervals, said recording device comprising search means for searching given portions of a track on the record carrier, scanning means for scanning the searched track portion by means of a write head for providing information patterns in the track, said write head being coupled to the input in order to provide an information pattern representing the supplied information stream in the scanned track portion, control means adapted to realise a search operation, prior to providing the information pattern, of an intermediate portion in the track released for recording, said intermediate portion being located between track portions in which the presence of an information pattern which is already present is to be maintained, said control means being further adapted to provide an information pattern representing the supplied information stream in the searched intermediate portion, characterized in that the device comprises an input buffer which is coupled to the input for receiving the information stream, and an output which is coupled to an input of the write head for supplying the information stream to be recorded, the device being provided with means for detecting, during scanning of the intermediate portion, when a position in the intermediate portion located proximate to the end of the intermediate portion is reached, means for interrupting, in response to the detection, the provision of the information pattern and for interrupting the information stream from the input buffer to the write head, and means for realising, in response to the detection, a search of a further track portion released for recording, for resuming the supply of information from the input buffer and for resuming the provision of the information pattern, the storage capacity of the input buffer being sufficient to store the presented information stream when the next released portion is being searched, the device being further provided with means for storing information indicating in which track portions the information patterns representing the individual information pieces are provided.

2. A recording device as claimed in Claim 1, characterized in that the control means are adapted to adjust the rate of supply of the information stream by the input buffer in dependence upon the filling level of the input buffer, such that the filling level remains between given limits.

3. A recording device as claimed in Claim 1, characterized in that the control means are adapted to interrupt the provision of the information pattern, to realise a scanning jump to a previously located portion of the track and to resume the recording when the track portion where the recording has been interrupted is reached again in response to a filling level of the input buffer, such that a filling level of the input buffer remains between given limits.

4. A recording device as claimed in Claim 1, 2 or 3, characterized in that the device comprises a data compression circuit which is arranged between the input of the device and the write head.

5. A record carrier comprising a track in which information patterns are provided which represent time-synchronous information pieces, particularly audio information pieces, characterized in that a track portion having an information pattern for another information piece is located between at least two track portions

which are not adjacent to each other in the track direction and have information patterns for the same information piece, while control information indicating the track portions in which the information patterns of the information pieces are located is recorded on the record carrier.

6. A reading device for reading a record carrier as claimed in Claim 5, which device comprises search means for searching given portions of the track on the record carrier, a read head for scanning the information patterns in the searched track portions and for supplying an information stream corresponding to the scanned information patterns, an output for supplying continuous and time-synchronous information streams, said output being coupled to an output of a signal processing circuit, characterized in that the device comprises an output buffer having an input which is coupled to an output of the read head, an output of the output buffer being coupled to the output of the device, the device being provided with means for interrupting the information streams to the output buffer on the basis of the control information recorded on the record carrier and for displacing the scanning to another track portion in which information patterns of a subsequent portion of the information piece to be read are provided after an end of a track portion with information patterns of the information piece has been reached.

7. A reading device as claimed in Claim 6, characterized in that the device comprises means for realising the supply of the nformation stream to the output buffer at a rate which is larger than the rate at which the information stream is supplied by the output buffer, the control means being adapted to realise an interruption of the scanning and the supply of the information stream to the output buffer, a scanning jump to a previously located portion of the track and a resumption of the supply of the information stream to the output buffer when the track portion where the scanning has been interrupted is reached again, such that a filling level of the input buffer remains between given limits.

8. A reading device as claimed in Claim 7, characterized in that a data decompression circuit is arranged between the output of the output buffer and the output of the device.

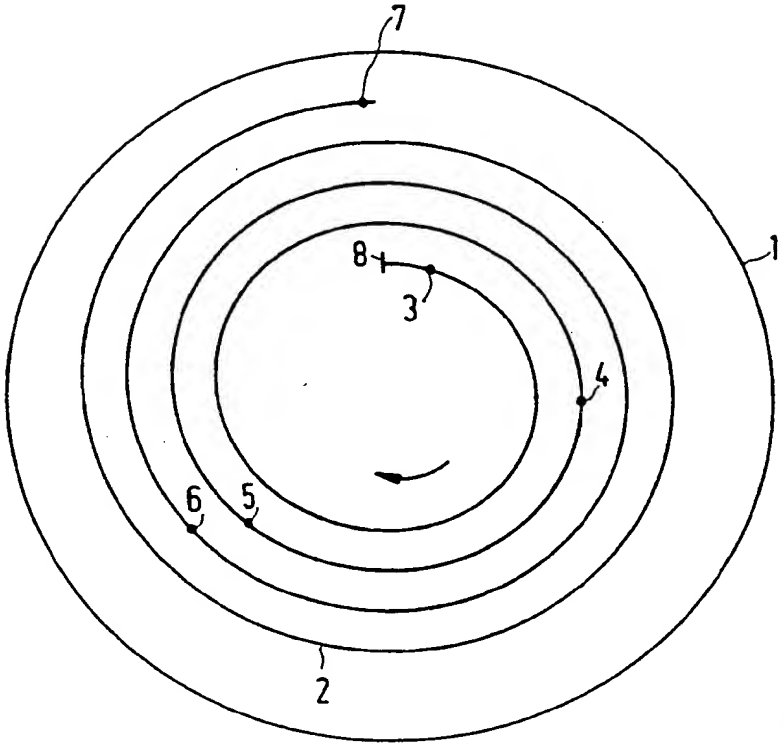

FIG.1

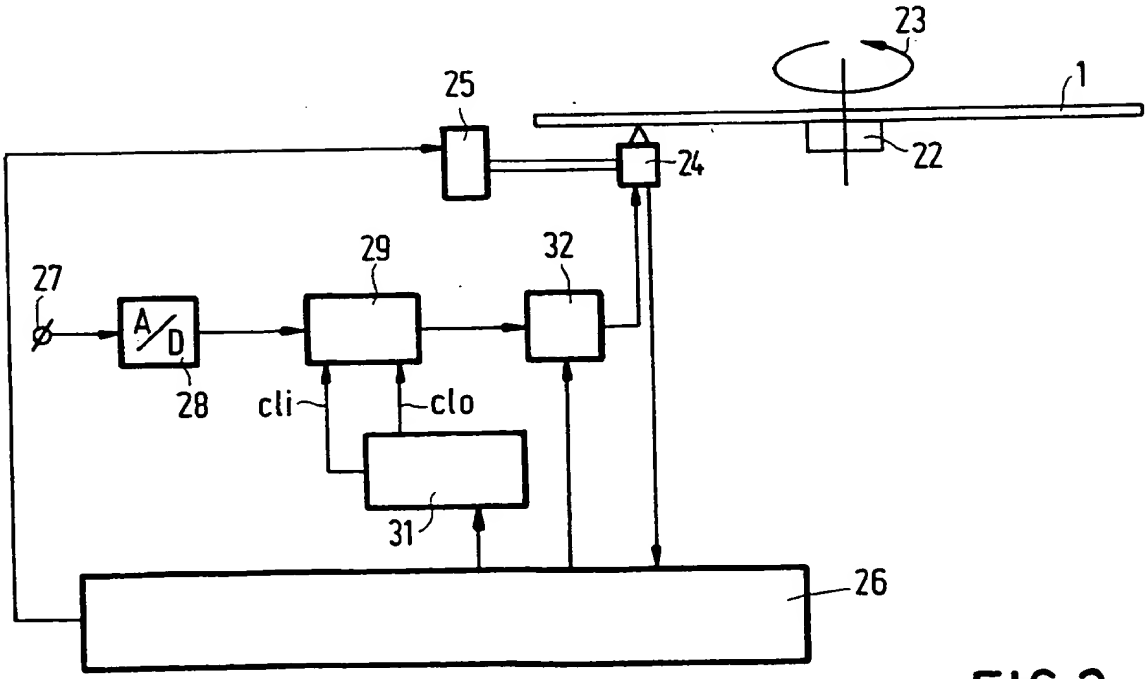

FIG.2

TNO	p	q	BA	EA
1	1	1	0'.7".0	22'.39".15
2	1	1	22'.39".16	45'.06".09
3	1	1	45'.06".10	58'.12".43

FIG.3

TNO	p	q	BA	EA
1	1	1	0'.7".0	22'.39".15
2	1	1	45'.06".10	58'.12".43

FIG.4

TNO	p	q	BA	EA
1	1	1	0'.7".0	22'.39".15
2	1	1	45'.06".10	58'.12".43
3	2	1	22'.39".16	45'.06".09
3	2	2	58'.12".44	65'.01".10

FIG.5

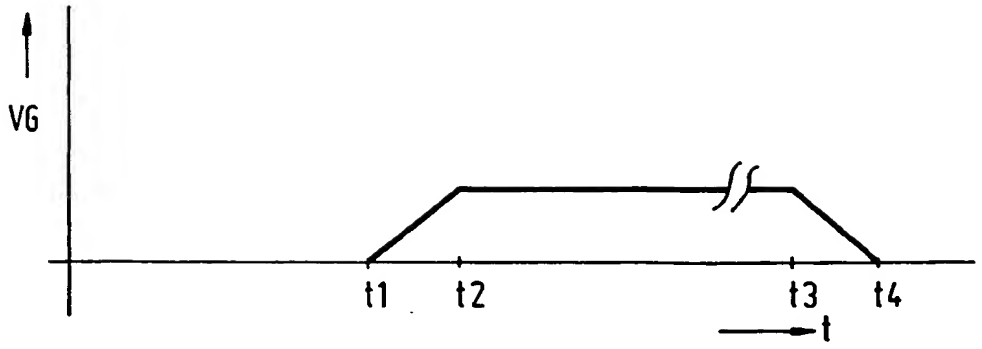

FIG.7

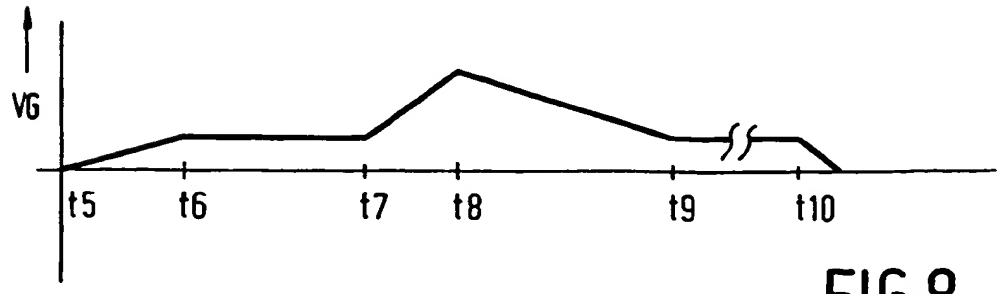

FIG.8

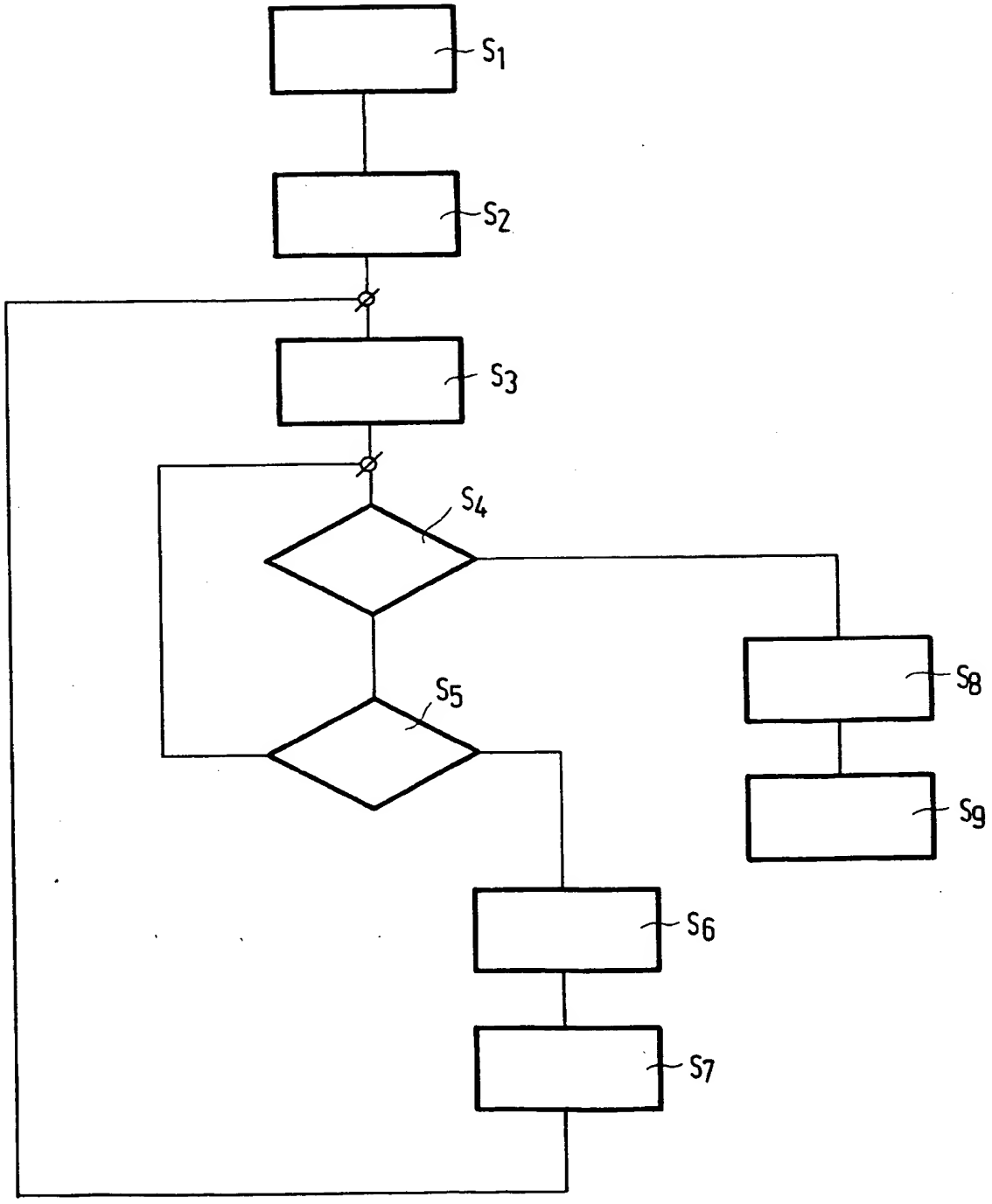

FIG.6

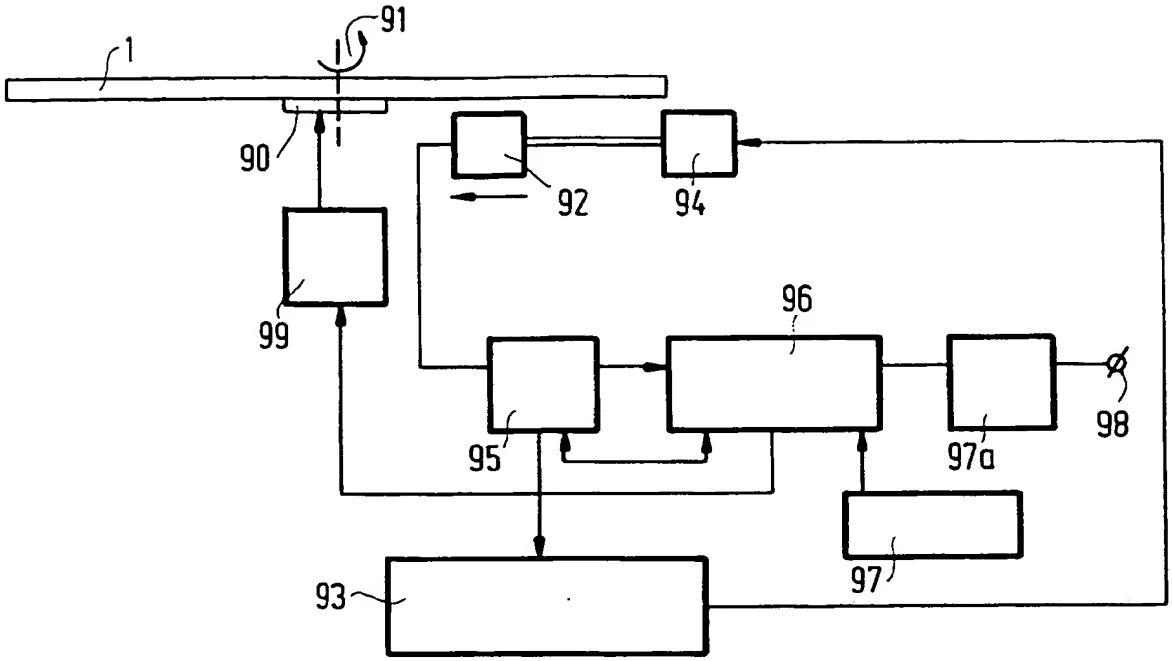

FIG.9

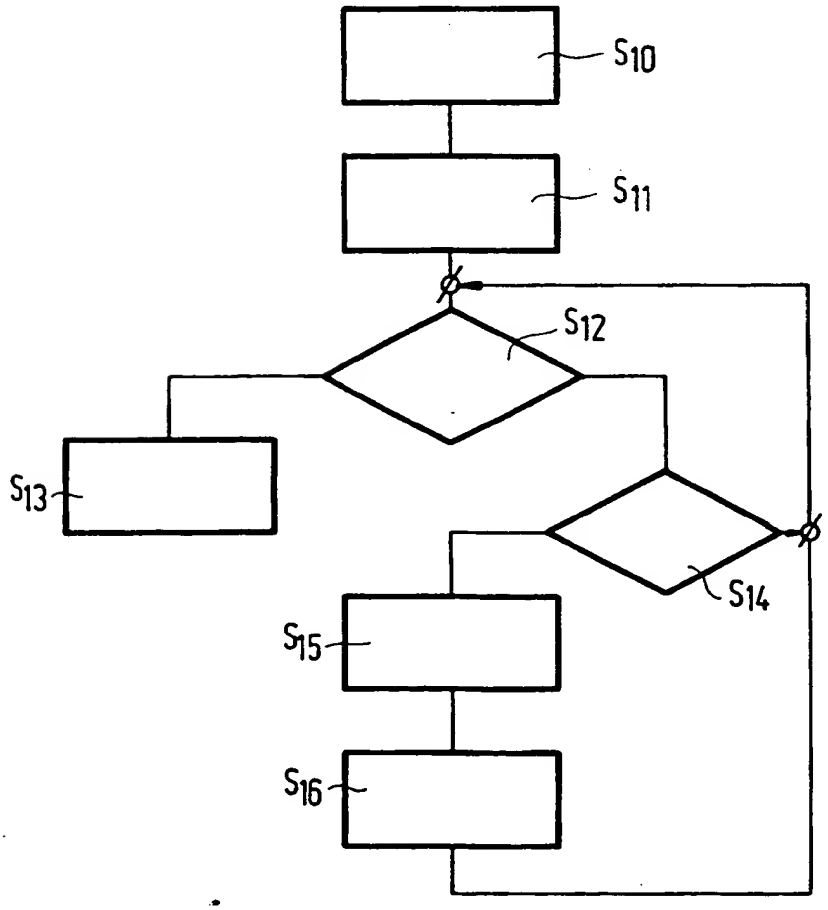

FIG.10

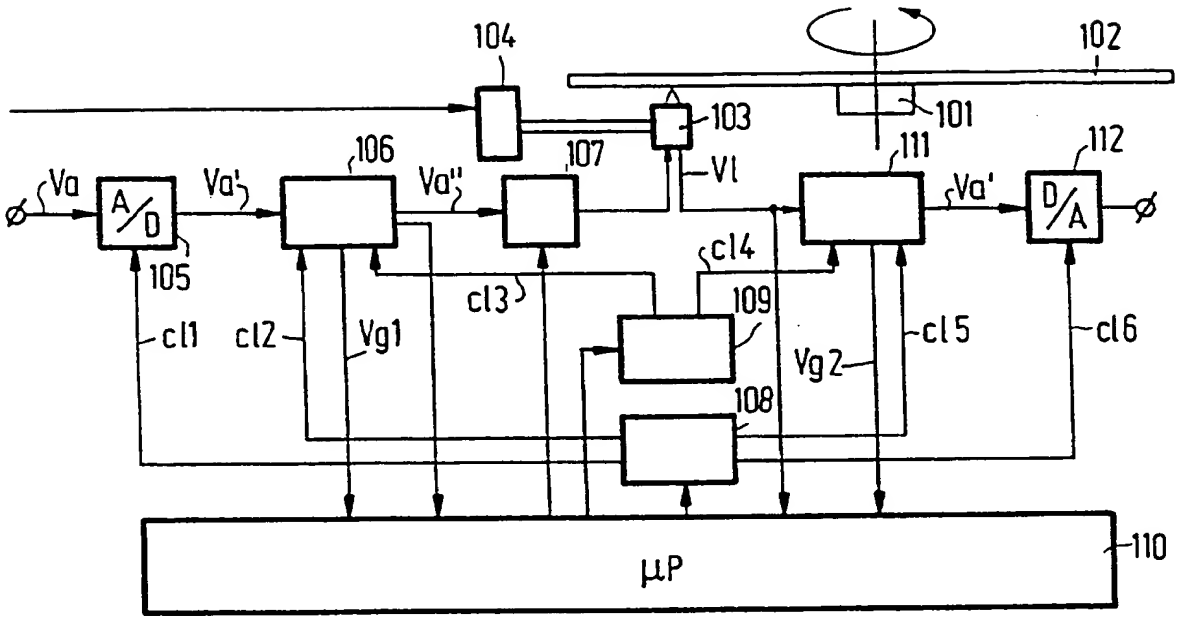
104
102
103
101
106
107
111
112
Va
A/D
Va'
Va''
Vl
D/A
Va'
105
cl4
cl3
109
cl1
cl2
Vg1
Vg2
cl5
cl6
108
µP
110

FIG.11

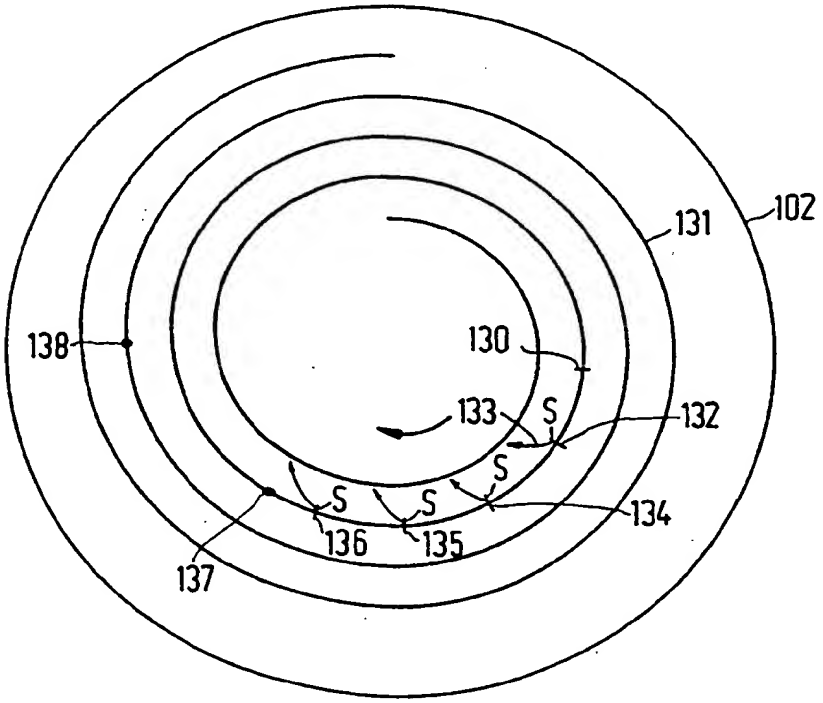
131
102
138
130
133
S
132
S
S
S
134
136
135
137

FIG.13

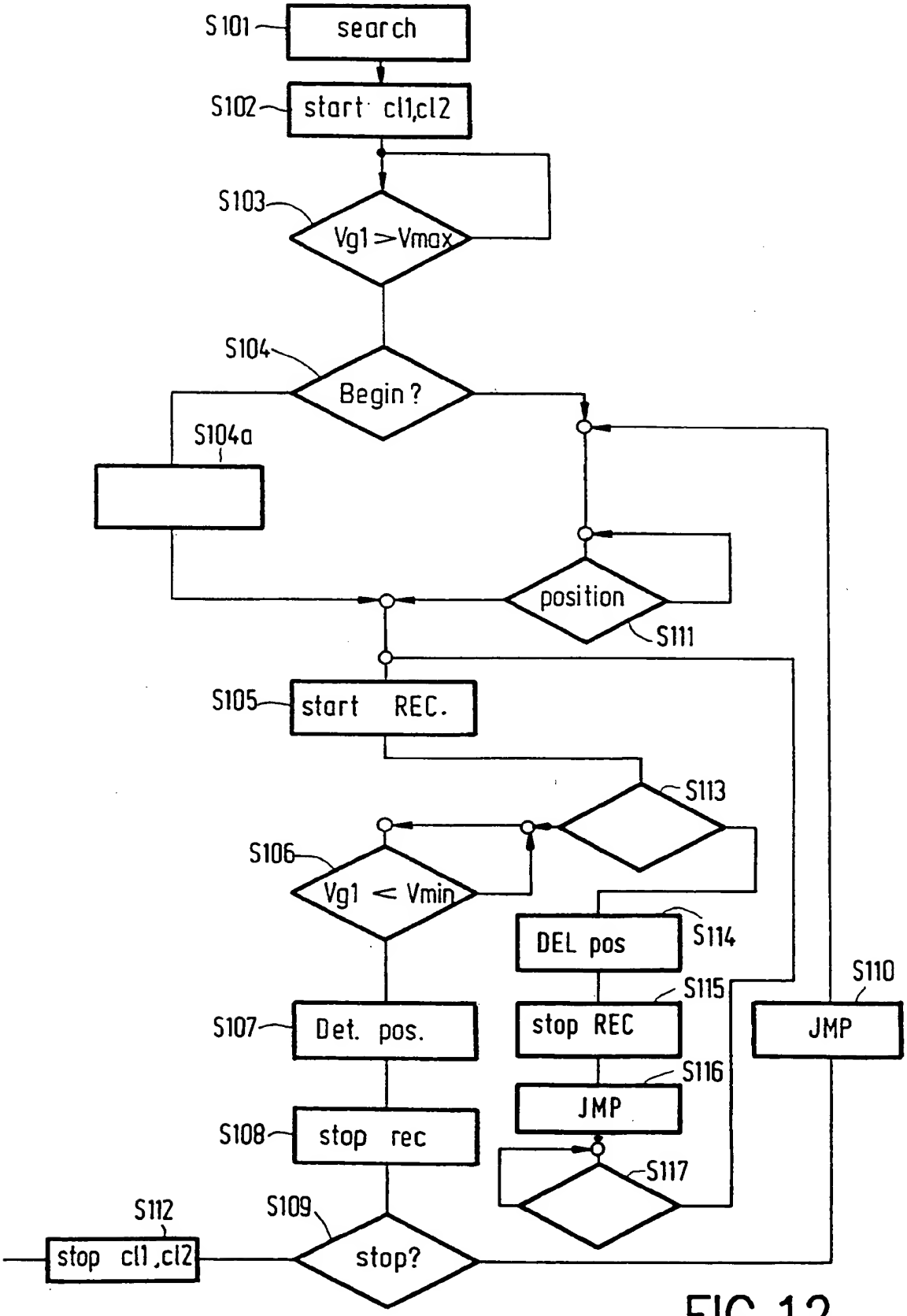
S101
search
S102
start cl1,cl2
S103
Vg1 >Vmax
S104
Begin ?
S104a
position
S111
S105
start REC.
S113
S106
Vg1 < Vmin
DEL pos
S114
S110
S115
S107
Det. pos.
stop REC
JMP
S116
JMP
S108
stop rec
S117
S112
S109
stop cl1,cl2
stop?

FIG.12

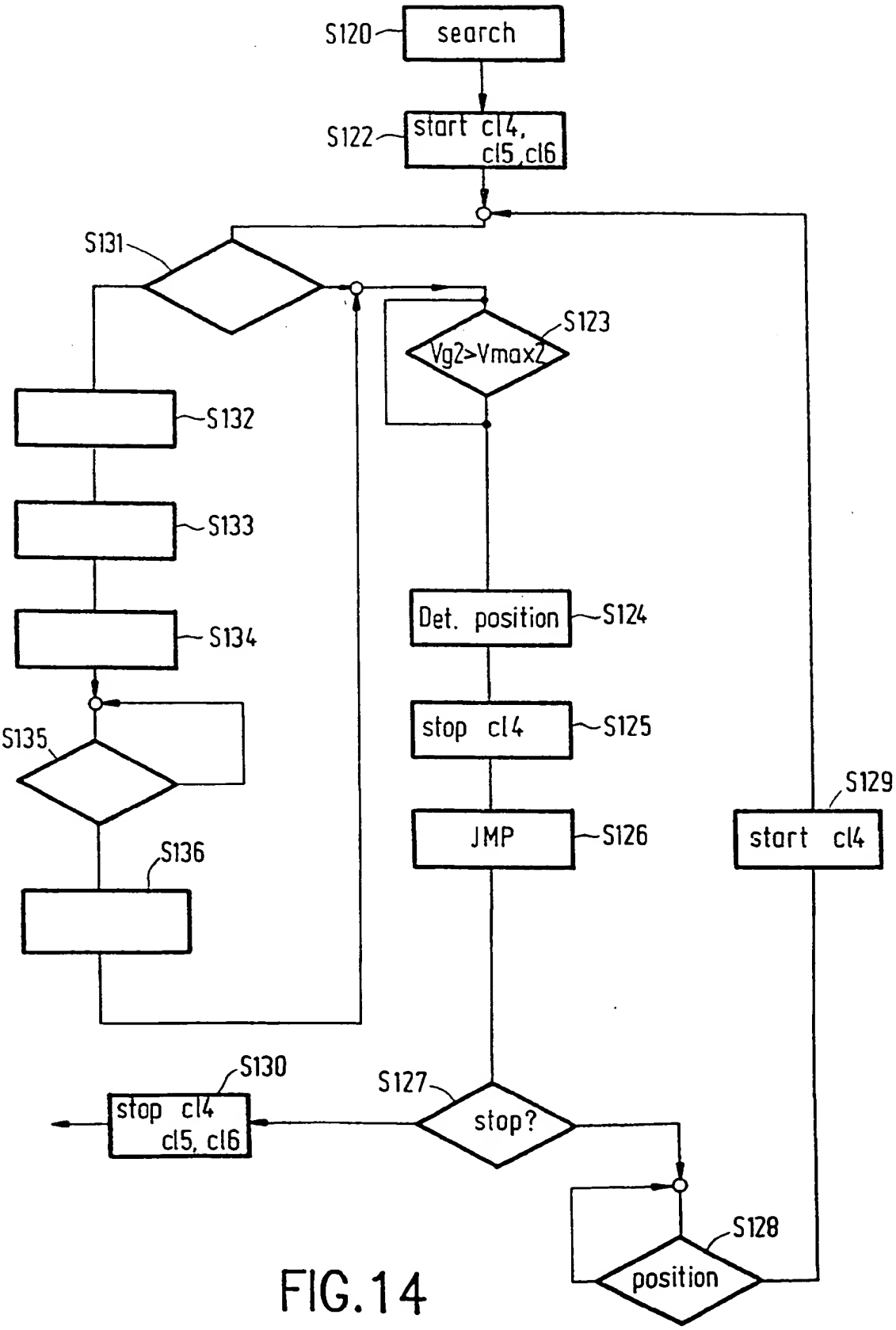
S120
search
S122
start cl4, cl5, cl6
S131
S123
Vg2>Vmax2
S132
S133
S134
S135
S136
Det. position
S124
stop cl4
S125
JMP
S126
S129
start cl4
S130
stop cl4 cl5, cl6
S127
stop?
S128
position

FIG.14

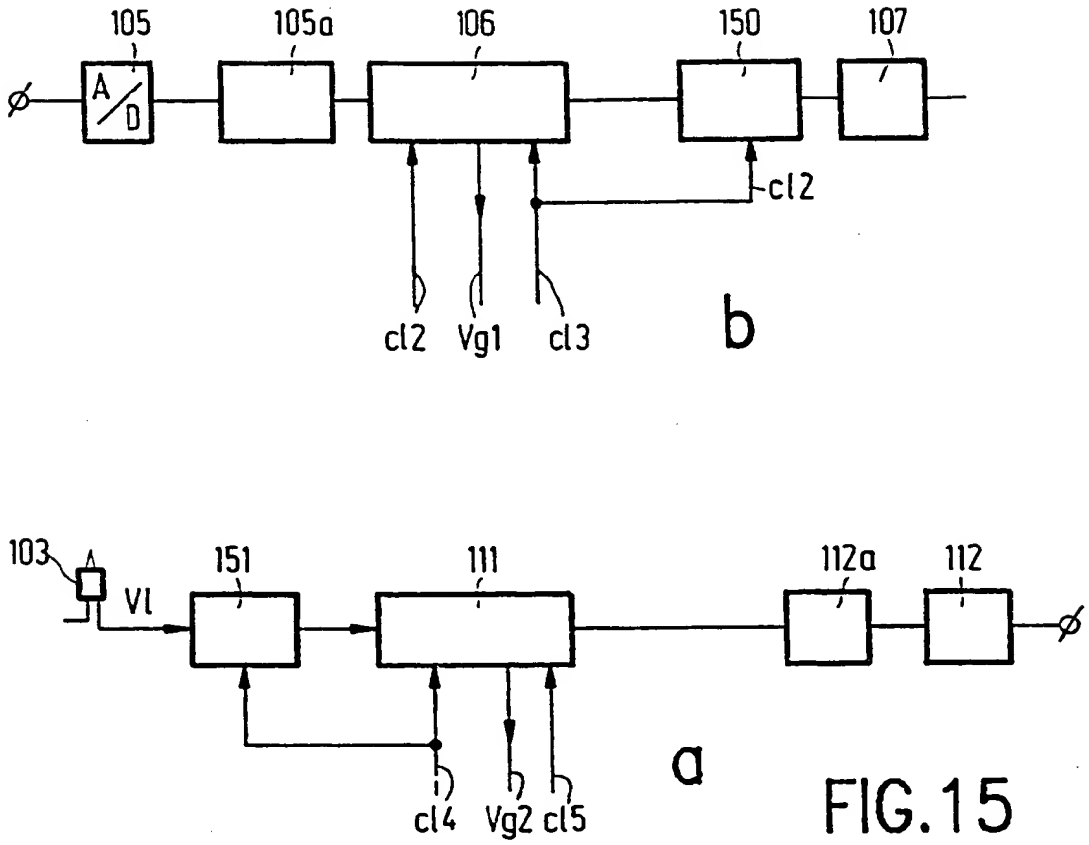
105
105a
106
150
107
A/D
cl2
cl2
Vg1
cl3
b
103
151
111
112a
112
Vl
cl4
Vg2
cl5
a

FIG.15

European Patent Office

EUROPEAN SEARCH REPORT

Application Number
EP 92 20 3455

DOCUMENTS CONSIDERED TO BE RELEVANT

Category	Citation of document with indication, where appropriate, of relevant passages	Relevant to claim	CLASSIFICATION OF THE APPLICATION (Int. Cl.5)
D,A	EP-A-0 275 972 (SONY CORPORATION) * page 4, line 49 - page 7, line 41 *	1,5	G11B20/10 G11B27/034
A	EP-A-0 399 853 (SHARP K.K.) * page 8, line 20 - page 10, line 55 *	1,5	
A	EP-A-0 288 571 (SONY CORPORATION) * page 13, line 13 - page 17, line 16 *	1,5	
D,A	EP-A-0 429 139 (N.V.PHILIPS GLOEILAMPENFABRIEKEN) * page 7, line 22 - page 12, line 25 *	2-3,6-7	
A	US-A-4 982 390 (Y.TANAKA) * column 6, line 26 - column 7, line 60 *	2-3,6-7	

TECHNICAL FIELDS SEARCHED (Int. Cl.5)

G11B

The present search report has been drawn up for all claims

Place of search	Date of completion of the search	Examiner
THE HAGUE	23 FEBRUARY 1993	KELPERIS K.

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